



UNIVERSITY OF
ILLINOIS
URBANA-CHAMPAIGN

PHYS 211

Exam 2 Prep

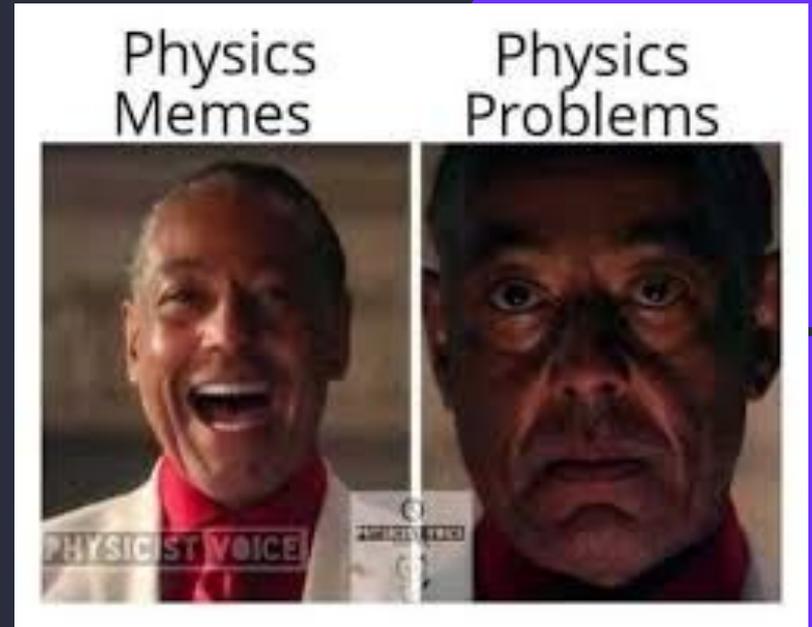


SCAN ME



1. Overview

Quick Bits of info to know





Forces

Conservative:

Path Independent

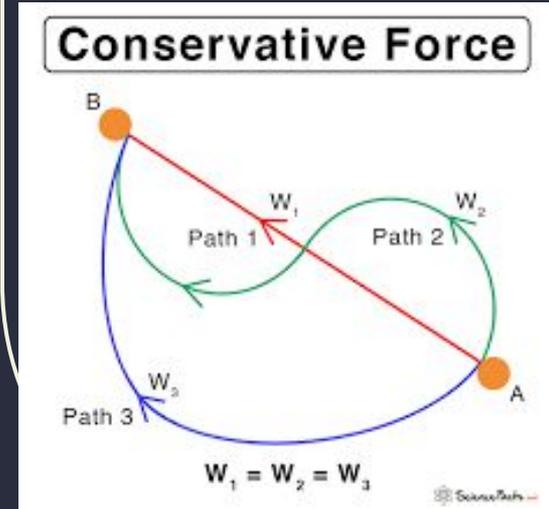
- Weight (gravity)
- Spring Force: $F = -k \Delta x$
- Potential Energy diff

Nonconservative:

Path Dependent

- Normal: Perpendicular to an object's surface by below surface
- Tension: points away from object
- Friction: $f = \mu N$

- X and Y components still apply, especially for ramp problems





Work

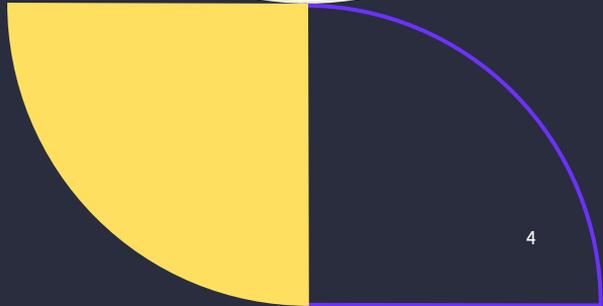
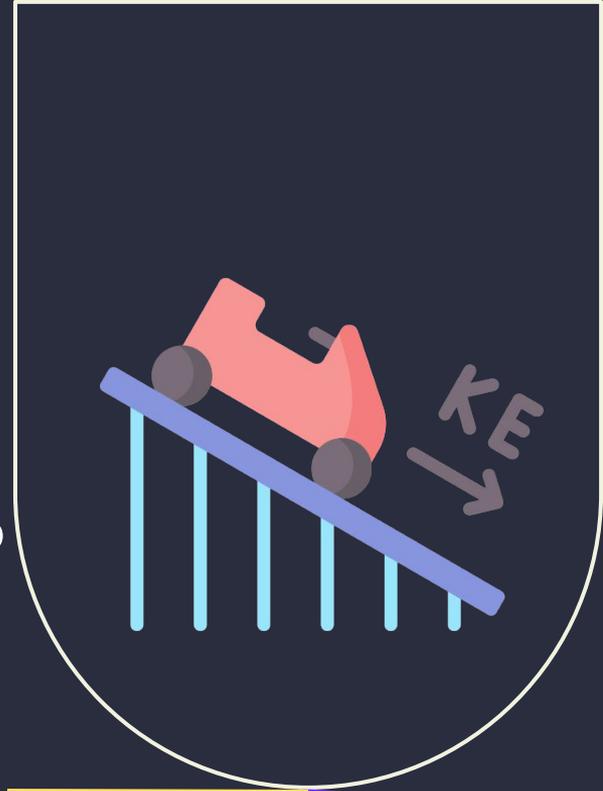


- **Work-Energy Theorem:** The work done on a system by the sum of forces acting on it is equal to the change of kinetic energy of the system,

$$\Delta KE = W = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

Ways to solve for Work:

- $W = F \cdot d \cdot \cos(\theta)$
- $W = -\Delta PE$ (for work done in a conservative field, such as dropping a ball with no air resistance)

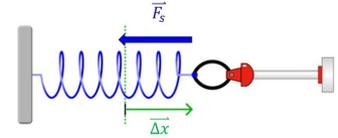


Work and Mechanical Energy

- For ΔE , you can choose whichever two points you want for the initial and final energy ($E_f - E_i$)
- Don't mix up potential energy equations with work equations.
 - i.e. $U_{\text{spring}} = (kx^2)/2$, but $W_{\text{spring}} = -k(x_f^2 - x_i^2)/2$
- Work and Energy are intimately related, using the theorems and conservation laws will help a lot!
- Total mechanical energy: $KE + PE = W_{\text{NC}}$

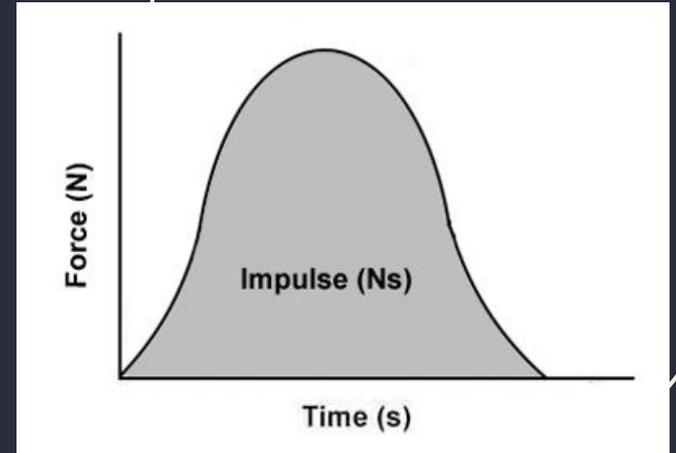
Spring (or elastic) Potential Energy

$$U_s = \frac{1}{2}kx^2$$



Momentum and Impulse

- $p = mv$
- $F_{\text{net, external}} = dp_{\text{total}}/dt$ $F_{\text{NET}} = \Delta p$
 - When $F_{\text{external}} = 0$, $dp/dt = 0$,
momentum is conserved
- Momentum is conserved in both the x and y direction
- Impulse: change in momentum
 - $I = F_{\text{AVG}} \Delta t = \Delta p = \int F dt$



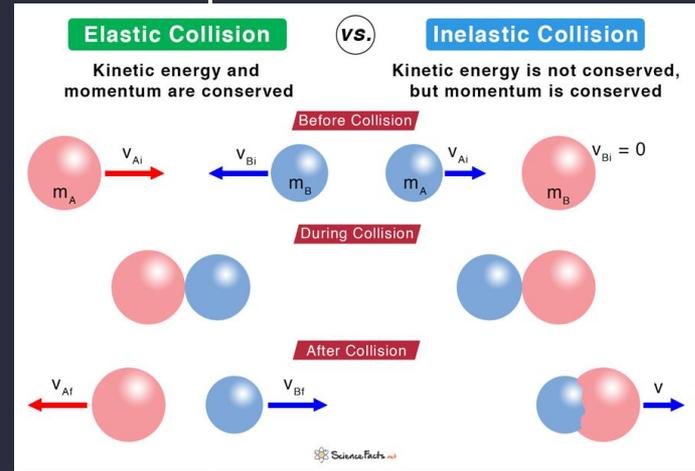
Momentum and Impulse

- **Inelastic**

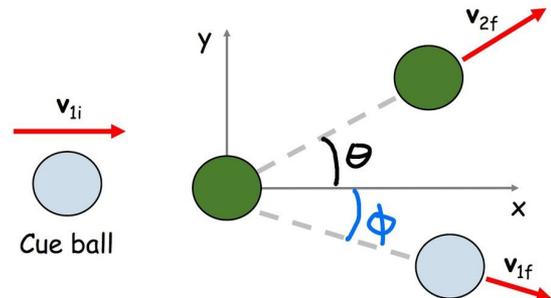
- Momentum Conserved
- KE is NOT conserved
- Objects can stick together
(*Perfectly Inelastic if they stick together*)

- **Elastic**

- Momentum Conserved
- KE Conserved
- Objects bounce apart



2D Elastic Collision



PHYSICS NINJA



Center of Mass + Frames

- For a system of objects, we treat them as point masses
- More massive object has more influence on center of mass

- **Lab Reference Frame:**

- Observe from outside system

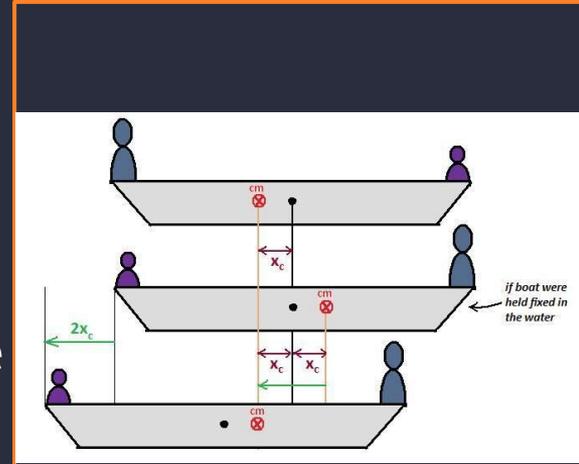
- **Center of Mass Reference Frame:**

- Observing from inside system
- $\vec{v}_{obj, CM}^* = \vec{v}_{obj, lab} - \vec{v}_{CM, lab}$

$$X_{CM} = \frac{\sum m_i x_i}{\sum m_i}$$

$$V_{CM} = \frac{\sum m_i v_i}{\sum m_i}$$

$$A_{CM} = \frac{\sum m_i a_i}{\sum m_i} = \frac{F_{Net, External}}{M_{Total}}$$

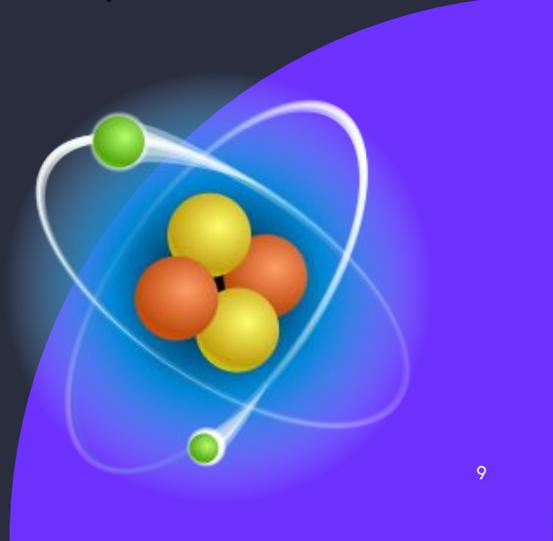


Transformation to the CM Frame

$$\vec{v}_{object, B} - \vec{v}_{CM, B} = \vec{v}_{object, CM}$$

2. Problem Solving

Some Steps to Follow If You Are Lost



Momentum

How to Identify:

- Collisions:
 - Billiards, Explosion, Fireworks
- Impulse



Momentum

- List given variables
 - In both x and y directions if necessary
- Identify if momentum is conserved (it almost always is)
- List all initial momentums and all final momentums
- Solve for missing variable
- *You will almost never need to use Kinematics, think of Energy, Work, or Momentum instead*
- Impulse:
 - Use F average



Before Collision

After Collision

	p Before Coll'n	p After Coll'n	Δp
Object 1	$m_1 \cdot v_1$	$m_1 \cdot v_1'$	$m_1 \cdot (v_1' - v_1)$
Object 2	$m_2 \cdot v_2$	$m_2 \cdot v_2'$	$m_2 \cdot (v_2' - v_2)$
System/Total	$m_1 \cdot v_1 + m_2 \cdot v_2$	$m_1 \cdot v_1' + m_2 \cdot v_2'$	0

Equation #1: $m_1 \cdot v_1 + m_2 \cdot v_2 = m_1 \cdot v_1' + m_2 \cdot v_2'$

Equation #2:
 $m_1 \cdot (v_1' - v_1) + m_2 \cdot (v_2' - v_2) = 0$
 $m_1 \cdot (\Delta v_1) + m_2 \cdot (\Delta v_2) = 0$
 $m_1 \cdot \Delta v_1 = -m_2 \cdot \Delta v_2$

CoM + Frames

How to Identify:

- "In _ reference frame"
- Canoe/Plank 
- Usually says "Center of Mass"

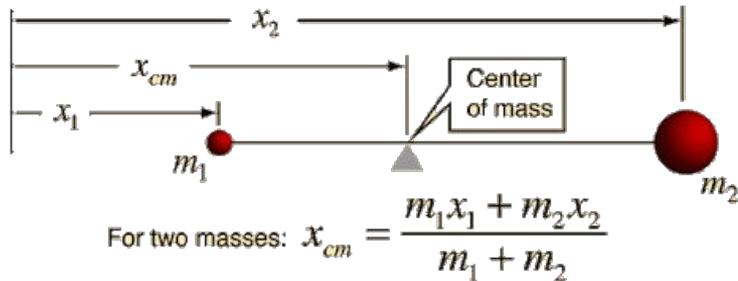
Center of Mass + Frames

Center of Mass

- Identify X_{CM} , V_{CM} if necessary
 - Pay attention to x and y direction

Frames

- List variables and their frames
 - V_{lab} , V_{cm} etc.
- Solve for the variable you're looking for



$$\begin{aligned} V_i^* &= V_i - V_{CM} \\ V_i^* &= -V_f^* \\ V_f &= V_f^* + V_{CM} \end{aligned}$$

$$V_{Lab} = V^*$$

Work/Energy

How to Identify:

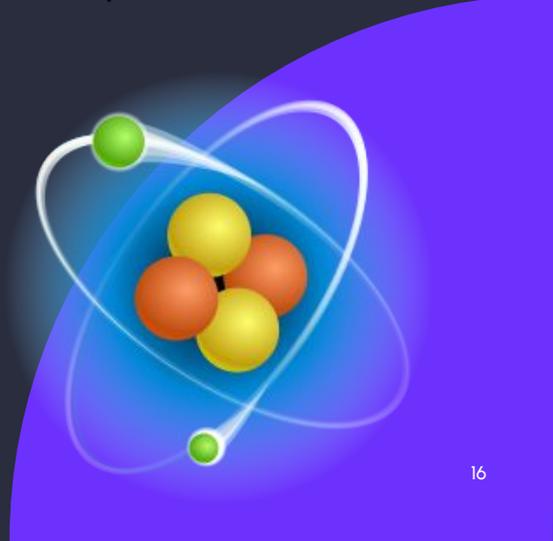
- Change in height
- Starts & ends at rest
- Kinematics/Force equations look too complicated



Work/Energy

- Conservation of Energy: $E_i = E_f$
- Work-KE Theorem: $W_{\text{NET}} = W_c + W_{\text{NC}} = \Delta KE$
- Conservation of Mechanical E: $W_{\text{NC}} = \Delta E = \Delta K + \Delta U$
 - Nonconservative Forces: Friction, Normal, Tension
- Choose the appropriate formula and plug in your variables to solve
- Make sure you have the right SIGN for work!
 - Remember, opposing force & distance $\rightarrow -W$
 - This is why W_{spring} is negative in equation sheet

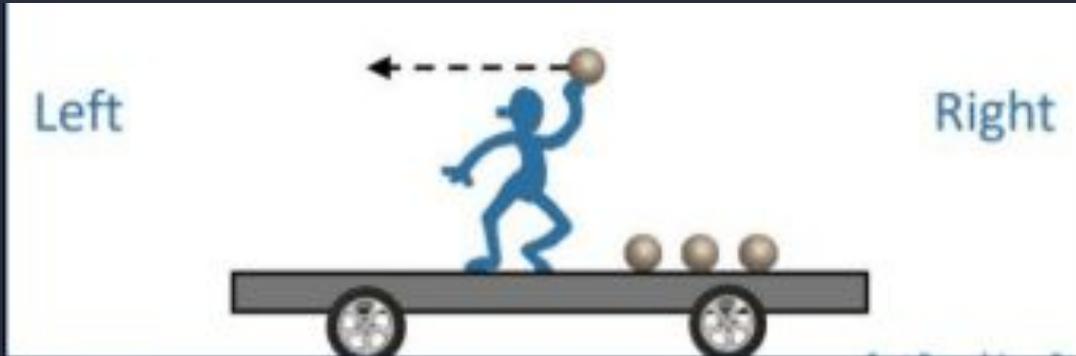
3. Practice Problems



Momentum Concept Question

How will the cart's position change?

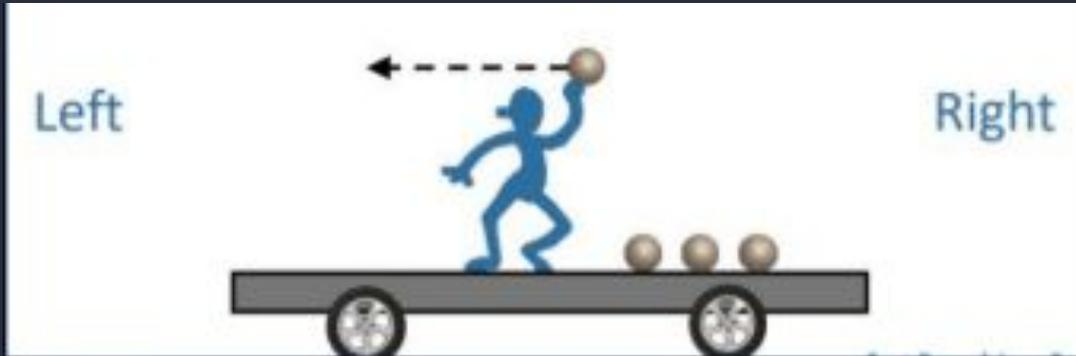
1. Move to the left
2. Move to the right
3. Will not move



Momentum Concept Question

How will the cart's position change?

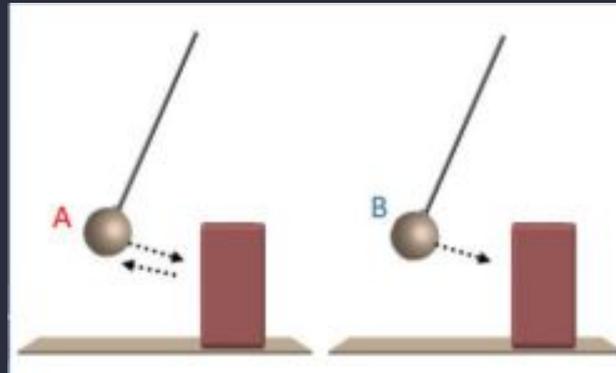
1. Move to the left
2. Move to the right
3. Will not move



Momentum Concept Question

Which brick will fall over and why?

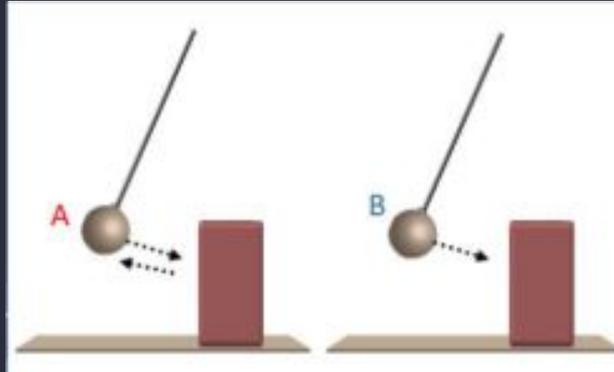
1. brick A
2. brick B



Momentum Concept Question

Which brick will fall over and why?

1. brick A
2. brick B

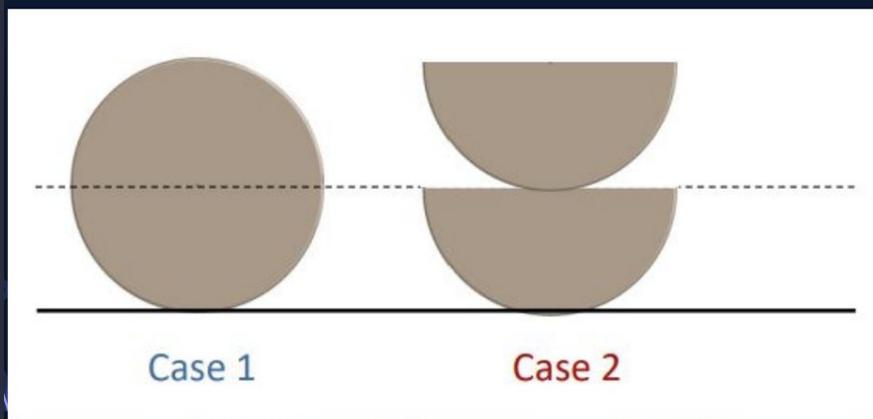


In Situation B more momentum is transferred into the brick in the forward direction!!

CoM and Reference Frames Concept Question

Which case has the higher center of mass?

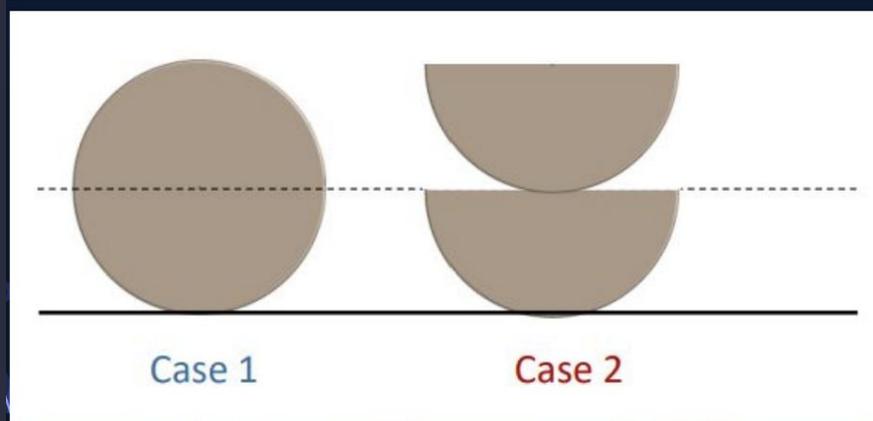
1. Case 1
2. Case 2
3. Same CoM



Solution: CoM and Reference Frames Concept Question

Which case has the
higher center of mass?

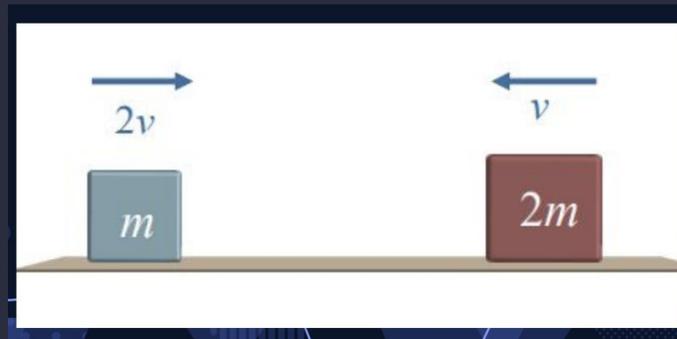
1. Case 1
2. Case 2
3. Same CoM



CoM and Reference Frames Concept Question

What is the momentum in the center of mass frame?

1. $2vm$
2. $-2vm$
3. 0



CoM and Reference Frames Concept Question

What is the momentum in the center of mass frame?

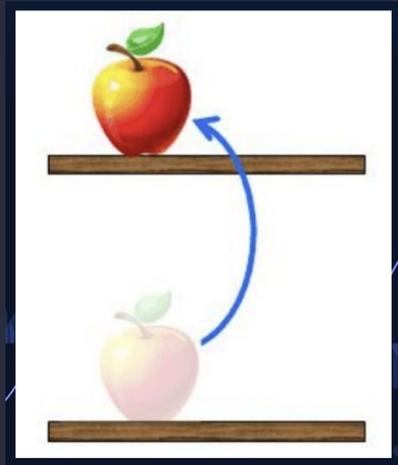
1. $2vm$
2. $-2vm$
3. 0



Work and Energy Concept Question

What is the net work done on the apple?

1. mgh
2. Zero

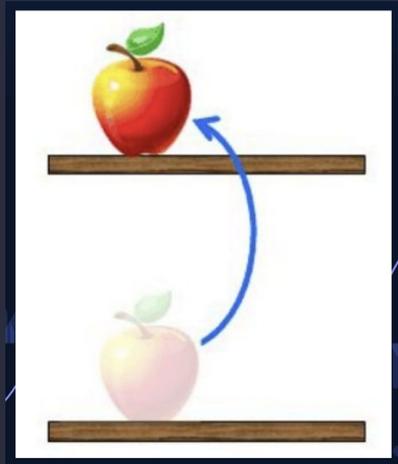


Work and Energy Concept Question

What is the net work done on the apple?

1. mgh
2. Zero

No change in KE!



Me: *Exhausted after carrying a box around for 2 hours*

Physics:



Work and Energy Concept Question

In what direction does the force due to static friction point?

1. To the Left
2. To the Right



Solution:

Work and Energy Concept Question

In what direction does the force due to static friction point?

1. To the Left
2. To the Right





Worksheet Time!

Enter Queue with your name and net ID:
By entering the queue, you help us:

- Reserve a big enough space at the next review session
- Assign enough tutors for everyone to have access to help

Thank you!

